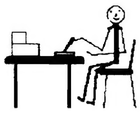
HOT IRON

Issue 5 *"Journal of the Constructors Club"* **Autumn 1994**



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Hot Iron is a quarterly newsletter for radio amateurs interested in building equipment. It is published by Tim Walford G3PCJ for members of the **Constructors Club**. Articles, suggested topics and questions are always welcome. Please send correspondence and membership inquiries to:-
Upton Bridge Farm,
Long Sutton, Langport,
Somerset, TA10 9NJ.
Tel & Fax 0458 241224
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EDITORIAL

I am pleased to be able to welcome some new contributors for the start of our second year with Hot Iron; David Sugden, G4CGS, offers a note on measuring inductance which I suspect is one of those things that many of us would like to do but can never remember an easy way - here it is! Incidentally, David does much of my PCB drilling for me and has to have some major surgery soon - we wish you well. We even have a letter to the Editor, (not invited by me!), with a most helpful suggestion on finding where to put parts into boards. Please keep the material coming - my material file is getting rather empty now! Alex Robertson, GM4IAO, has pointed out that my words on the copyright of material published in Hot Iron maybe putting off contributors - I hope that this is not the case because I certainly have no desire to make any commercial gain out of other peoples ideas. It is there to give some cover, albeit rather thin I think in reality, from others trying to make something of my own ideas. In fact you will find that the publisher, practically without exception, will retain the copyright for all material in his journal irrespective of whether he paid a fee for the article or not. For example, the contributions to RadComm's Technical Topics, are covered by the general copyright for the whole magazine. Please tell me if you feel inhibited by this copyright aspect.

At last I am able to tell you about my IF amp for the Yeovil, it should also be useful for Tiny Tim but to date I have not tried it out with TT. I do find that the MF Booster does go very well with Tiny Tim; I had some very good reports when working with an 80m dipole clear of all buildings in a field with the rig under a fertiliser bag due to a downpour just prior to our Wessex Clubs BBQ on July 30th.! The rain neither put out our spirits or our fire! Tim Walford Editor 30/08/94

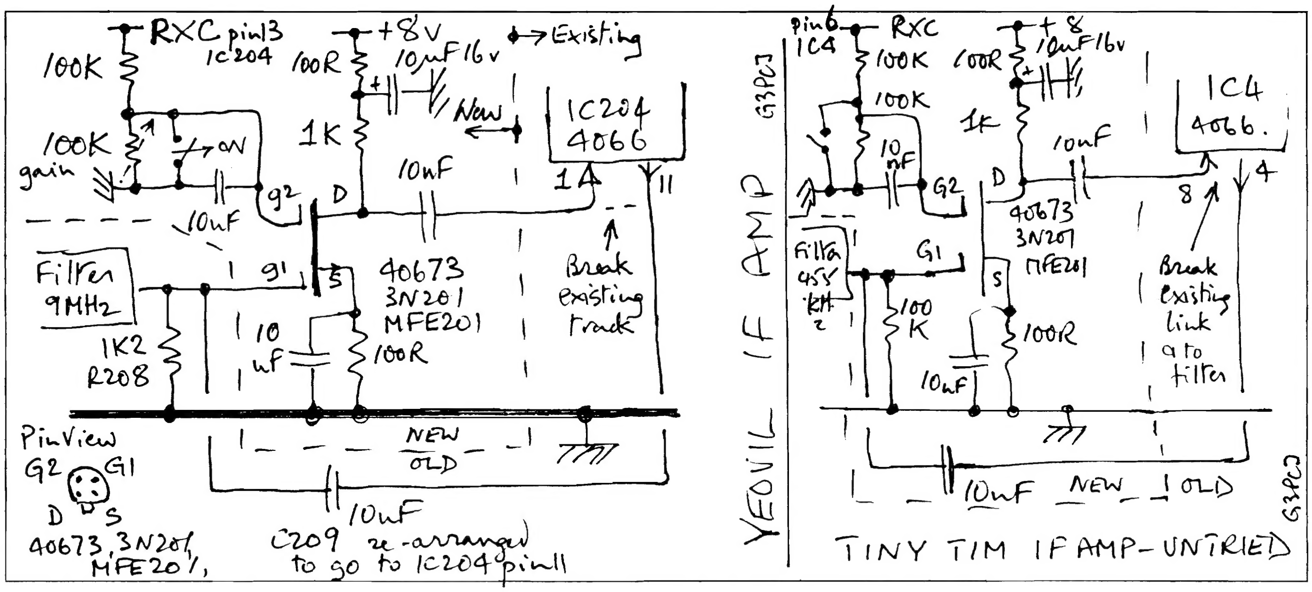
Snippets

Craig Douglas, G0HDJ, has sent in a couple of snippets. Firstly that SMITH KENDON travel sweet tins have many uses in the shack! Apart from storing spare parts, they make excellent cases for small items of test equipment and are also suitable for supporting a PCB when soldering the underside connections. The tin has sufficient dept for the parts to not hit the bottom, the width gives it stability and there is enough room for a damp sponge for cleaning the soldering iron tip! He has also solved the problem of where to find plastic knitting needles which are a vital tool for adjusting the ferrite cores of Toko coils and the like. Visit your local shop specialising in second hand furniture and house clearance - a good rummage around and you might find some without the steel cores of the plastic coated variety - see if you think you can snap them before buying! These shops also have old radios with large air spaced variable capacitors.

Stan Knight, G0BGI, has asked for advice on static precautions in regard to FETs and CMOS devices. Its a big subject but the best advice is to assume that all active devices maybe subject to damage and thus treat all equally carefully. Some may have protective zeners but dont rely on it! As I live in an old damp farmhouse, there is usually sufficient moisture about for there to be a leakage path practically anywhere! You should keep parts for as long as possible in static discharging black carbon loaded plastic bags, or in similar carbon loaded foam plastic or with their leads rammed through kitchen foil wrapped around a polystyrene block. If your shack has a very dry atmosphere which might cause problems, you should earth yourself, your iron and the item being assembled, frequently to mains earth. You can regularly touch the exposed metalwork of some piece of mains earthed equipment, or better still, wear an earthing wrist strap. A stripped flexible lead wrapped twice around your wrist and connected to a suitable mains earth point should help and do also earth the PCB. Do be CAREFUL to get mains earth and not the live line. Do not connect to an RF earth. Never insert parts into live circuitry.

IF Amplifier for the Yeovil

The correct place for a receiver IF amp is after the IF filter and before the second (product) detector. When Derek Alexander, G4GVM, tried his IF amp in this location he was unable to control the ensuing hooting so he moved it to before the IF filter - see Hot Iron 2. My own efforts were equally useless until I realised that the feedback was audio from the rig output stage, through the 12 volt supply to the extra IF amp and into the product detector and hence round again etc. It needed about 10,000 ,uF on the +12 volt line to stop this! Luckily it is quite in order to use the +8 volt line where the feedback path is broken by the regulator. The basic circuit uses one device with a few resistors and capacitors which can be mounted ugly style with short leads so I dont think a PCB is necessary. It does required that a track be cut between pins 1 and 11 of IC204 and I would suggest that you drill four small mounting holes for the dual gate FET in the space between R208, R205, C211 and C209 which has to removed/rerouted to pin 11 of IC204. The device leads are pushed through these holes with all the other parts mounted by their leads between the transistor and other rigid connection points on the underside of the PCB. It is important for the filter pin connections to be short as it is very prone to picking up BCI. Only use the earthy ends of R208 and C213 for making earth connections. Any of the three transistors listed should be suitable. The amplifier gives about 10 dB gain and it will slightly increase the apparent RX noise level when no signals are present as it amplifies front end noise, however the AGC action comes into effect at lower levels when signals are present and this depresses the noise. The 100K shown as a variable can be used as an IF gain control or replaced by a fixed resistor, with or without the switch to reduce the gain. In practice most people would leave it on full gain the whole time. Increasing the IF gain decreases the threshold of AGC action and you may find that the S meter reads continuously even without a signal present. The cure, if required on your rig, is to reduce the AGC loop gain by reducing the value of R110. This is most easily done by tacking say 100K in parallel with R110 under the PCB. (It is possible to replace the 1K drain load resistor of the IF amp with a 9 Mhz parallel resonant circuit; this will give greater gain but you will definately have to reduce R110 and the recommended 1K is much easier to install and will suit most people.) In principle this circuit can be added to **TINY TIM** since it will work equally well on 455 Khz; however the pin numbering is different and parts are needed for the DC biasing of gate 1. G3PCJ



Yeovil tuning controls

G4GVM tells me that he is working on a scheme to make the main tuning of the Yeovil always give increasing frequency with the same rotation and at the same time limit the coverage to just the appropriate band segments, rather than the normal 500 Khz. This uses presets and a potiometer with slow motion drive - details in the next issue. G3PCJ

Frequency Counter as an instrument

One counter, returned for investigation of random readings with no input, showed symptoms of instability and noise on its +5 volt line caused by the input logic gates not having any signal to switch them fully to their normal digital output levels. By applying DC feedback around the CMOS gate, its output is forced sit at mid supply level and in doing so draws rather more current from the supply than is normal for a CMOS gate. This in turn causes the supply to droop a little and the gate to oscillate at around 100 Khz. This oscillation does not occur if there is an input signal since this drives the output to the supply limits in the normal manner for a logic gate; hence if the counter is installed permanently in a rig, it always has the oscillator signals driving it and the fault does not show up. Only when its used as test gear and there are no signals does it show - the cure is easy; add a 100 ,uF 16v decoupling capacitor to the +5 volt line. The same unit also had another fault; a regular beating of the display between two values when the input was in a certain frequency band. This was located to a missing earth point connection for one of the counter chips! G3PCJ

Measuring Inductance

Most amateurs own a multimeter which will enable them to measure resistance. A few will own either a capacitance bridge or one of the newer digital multimeters which has a facility for measuring capacitance. Not many have anything for inductance but with simple gear and ingenuity it can be done. The methods described require some simple calculations and will give an accuracy of around 10% which is good enough for most purposes. For inductances up to about 2 milliHenries, the simplest method is to connect a known capacitor in parallel with the unknown inductor and determine their resonant frequency. Its worth remembering that all inductors have some self capacitance so a fairly large value should be used to swamp the unknown self capacity. Having determined the resonant frequency the value is determined from the standard formula:-

$$f = \frac{1}{2\pi\sqrt{LC}}$$ f in Hertz for L in Henries and C in Farads OR $$f(\mathrm{Mhz}) = \frac{159}{\sqrt{L_{\mu H} \times C_{pF}}}$$ f in Mhz for L in μH and C in pF

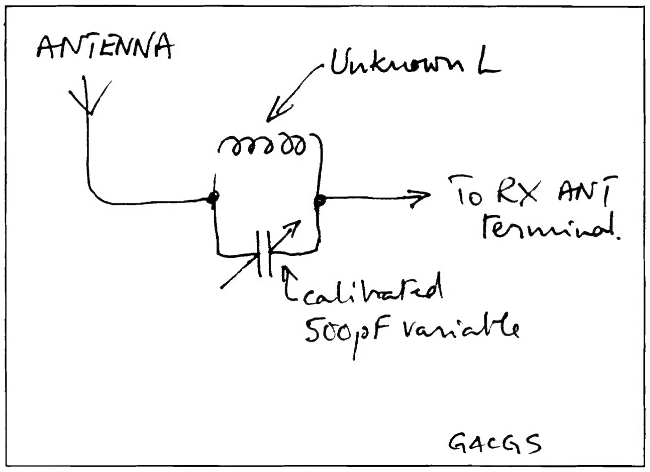
There are at least two other methods.

1. Using a Grid Dip Oscillator

Connect a known close tolerance capacitor across the coil and search for the dip which indicates the resonant frequency. If you always use a 250 pF fixed capacitor, calculation is simple. Take the frequency in Mhz, multiply it by itself (square it) and divide the result into 100. The answer is the inductance in μHenries. If this produces an abnormally low frequency, try repeating the test with a fixed 25 pF capacitor, but this time divide the square of the frequency in Mhz into 1000. Again the answer is in microHenries. Easy isn't it? What no GDO! Then use your RX.

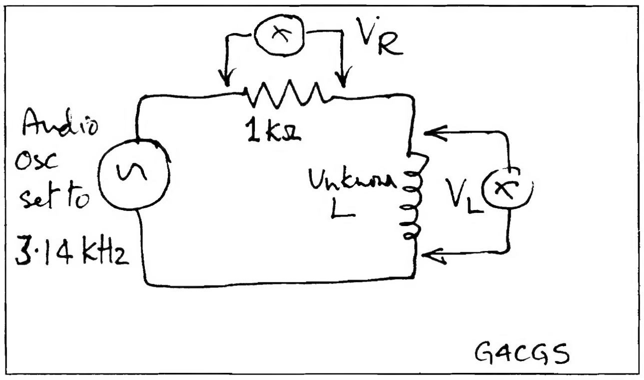
2. Using a Receiver

This method makes use of the fact that a parallel connected coil and capacitor combination connected in series with the antenna lead of the receiver will act as a rejector circuit. At its resonant frequency, the rejector circuit exhibits a high impedance and rejects signals of that frequency. Here we use a 500 pF variable capacitor fitted with a pointer knob and scale calibrated at 50 pF intervals using a capacitance bridge. The variable has short leads with crocodile clips to attach it to the unknown which is placed in series with the receiver antenna lead. Simply tune in any steady signal on the receiver and rotate the variable capacitor until there is a sudden loss of signal. Note the frequency and value of capacitance; find the inductance by inserting them in the above formula or using charts which are available. With the capacitor variable between 50 and 500 pF giving a 3 to 1 frequency range on any coil, an HF receiver with coverage of 500 Khz to 30 Mhz will cover inductances from 0.1 μH to 2 mH. This will cover most coils used in RF work but what about those for audio work?



Measuring Reactance

For coils of relatively large value, the above resonance methods become impractical; instead we measure the impedance of the coil at a known frequency. We need an AF oscillator capable of a volt or more output and some sort of voltmeter suitable for measuring the audio frequency voltages. Simply connect the coil in series with a known non inductive resistor across the output of the oscillator. Since the same current flows through the coil and resistor, we can use a voltage measurement across the resistor to measure the current in the coil, which can be used with the voltage across the coil to obtain its reactance and from that, its inductance. The maths is a little tiresome but we can simplify it by always using a 1000 Ohm resistor and using a fixed frequency of 3.14 Khz for the audio oscillator. Connect up as shown and measure the voltage across the resistor, call it V_R then measure the voltage across the coil, call it V_L. Note that if these two numbers are simply added together they will not equal the voltage applied from the oscillator since the voltages have different phase relationships. For this reason the voltmeter used must be isolated from the audio signal generator. Insert the measured values into this formula and the result is in milliHenries:-



$$L(\mathrm{mH}) = \frac{50 \times V_L}{V_R}$$

Measuring inductance is certainly not as easy as measuring resistance or capacitance but with a little ingenuity quite good results can be obtained.

David Sugden G4CGS

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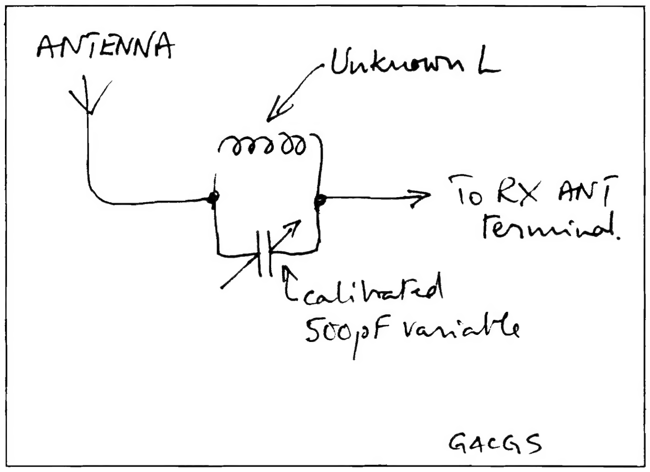

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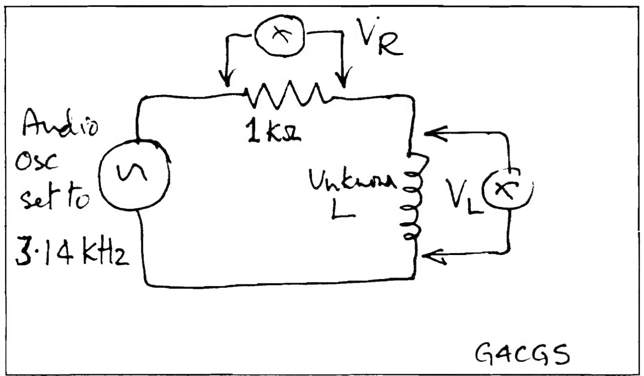

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Fault finding

Quite often I find people unsure what one ought to do when confronted with a dead electronic beast. (Please excuse my farming background!) Herewith some suggestions written as though you are examining something built by somebody else. If you have built it, the principles are just the same. If it has worked in the past, then damage physical or electrical (blown devices) is most likely. If it is a kit that has never worked go back and reread the instructions doubly carefully for things you failed to do; incorrect parts placement is quite common. The sort of fault where parts go out of tolerance with age or where the design was marginal in the first place are likely to be pretty rare and cause much sweat even if you have good test gear! There are three main stages in fault finding; a good physical examination, followed by tests you can do easily and finally, less easy tests with measuring equipment. The basic principle of fault finding (with the device switched on) is to assess the output responses to any form of input. The further the input is from the output, the more uncertainty there is which makes it necessary to keep on dividing the section being tested in two until you have found the fault. If there is no response to your first test, either move the input signal halfway towards the output or the output halfway towards the input. If the enclosed stages now work you know the fault was in the other half. Transfer the input and output evaluation points to the non-working section, check its not working and divide into two as before. Keep on doing this (within the convenient possibilities that you have for injecting test signals and evaluating the response) until you are down to just a small group of parts.

The physical examination involves looking for signs of mechanical or electrical damage inside and out - broken and bent parts, loose and poorly insulated wires, melted or lifted tracks, swarf and solder splashes etc. Pay particular note to the points where there should be ground plane solder connections on the top side of the PCB as well as on the underside. Unless there have been board drilling mistakes, there should be no countersinking for these points on the ground plane side. Failure to make these top side solderings, because it fails to link underside ground connections to the ground plane, is the most common cause of malfunction in my kits. Also examine carefully the quality of soldering; are the joints well shaped, bright and well adhered to the component wires? Again ground plane solderings are prime candidates - notably disc ceramic capacitors which don't always tin very well close to their body and may need their leads scraping. At this stage look for parts that are bent over, or inserted too far, that might be shorting to the ground plane; worst offenders are ICs pressed in too far before soldering, Toko coils that have pins with shoulders, and preset resistors. Any wiring to the front panel should have short leads laid away from sensitive areas such as VFOs and high impedance low level signal stages (audio pre-amps). I prefer to lay wires tidily but NOT laced on the topside against the ground plane since this helps to screen them from the tracks underneath. Front panel earths should also be short and thick - particularly for gain control earths - they should connect direct to the front panel ground plane if fitted, which should be soldered every inch or so to the main PCB ground plane.

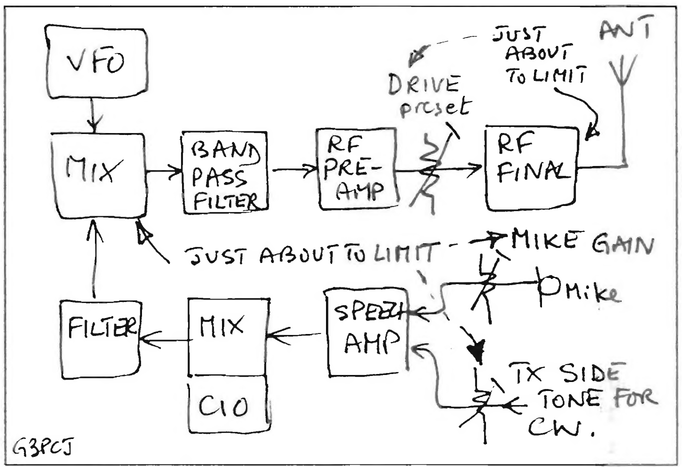
After passing, and maybe rectifying any defects of the physical examination, make the external connections and apply power of the right polarity. Watch out for unreasonably high supply currents. Examples of easy tests which you might do first are to listen to the output of a RX or to measure the output of a TX. If there is nothing at all, not even at a very low level, the output stage is likely to be dead but if there is a hiss or any very low level RF output, then its likely the trouble is earlier. See if it works on any other bands or in any other modes - do any of the controls have any effect - as expected or otherwise? Carrying on with the easy tests, you might see if it responds to the application of a finger to the hot end of the audio gain control. This is a crude test of the following audio stages and you should find your finger causes a hum - unless of course there is a nasty narrow CW filter in between which would reject the 50 Hz! That tells you that you should have made certain the controls were set correctly for the sort of test you are performing. (Be very careful when doing any tests with valved rigs having high voltages and the finger test is best avoided just in case a coupling capacitor is leaky.) Probably the most valuable thing to do next is to check all the supply voltages and particularly any internally derived general supplies - do they have the right levels and do they change in an unexpected manner when the controls are operated? After this its worth seeing if the oscillators are working because that can often be done easily. Use a RF probing voltmeter, scope, counter or a general coverage receiver with its aerial lead draped over the suspect oscillator. Tune the test RX around the expected frequency and remember to alter the oscillator's tuning (on a VFO) just in case the vanes are bent and touching etc. If it is a crystal oscillator you should know exactly where to look.

If these relatively easy tests fail to identify the problem area you will have to inject known carefully controlled signals, audio, RF or whatever, and measure the output with appropriate voltmeter, scope etc. Since we havn't yet had much in Hot Iron on items of such test gear, I cant go much further in this article. I hope later to have something on test oscillators, broadband amps and attenuators etc to compliment the RF power meter described in Hot Iron 3. Similarly for audio test gear. However by far and away the most useful piece of commercially made test gear is a scope if you are thinking of spending some money - they are now very good value for money and its not practical to build you own. (I would rather spend £300 on a scope than on a new rig!) If you can, go for one with a bandwidth of 20 Mhz or more. Most nowadays have two channels but its not essential. Surplus sales and rallies are good sources for your first, but once you have had one, you will soon realise their value and want a better one! New dual channel 20 Mhz scopes start at about £300 including probes. Assuming that you have various oscillators and measuring instruments you will soon find you want a counter. Don't forget the Walford Electronics counter which works to 60+ Mhz and will soon be complimented by a kit to give it instrument style facilities using Radio 4 for the reference. Details out soon. G3PCJ

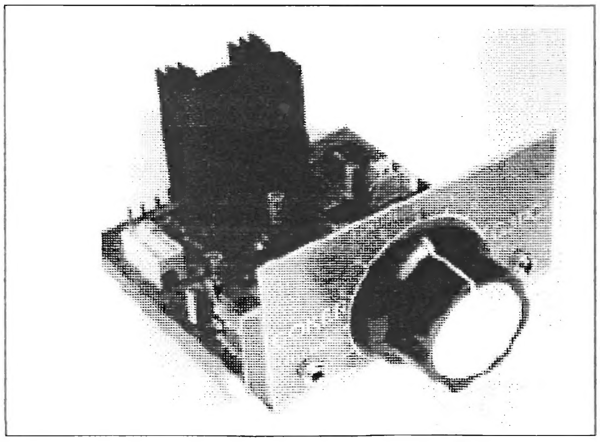
RF Output Limiting

Tony Measures, G3WUC, asks what are the signs of output limiting. He felt that he might have increased the drive preset in his Yeovil too far leading to a poor QSO. I think that most receiving stations, certainly at a distance, are unlikely to be able to tell whether the transmitter is limiting in its RF output stage; to the distant station, when correctly tuned to the nominal carrier frequency, it just sounds normal. To a nearby receiving station, the symptoms would be splatter on both sides of the transmitter's frequency. The width of such splatter is dependent on the degree of limiting, the radiated power level of the unwanted signals, distance etc.. In bad cases it can extend 50 or more kiloHertz either side of the nominal frequency and be detectable tens of miles away even from moderate power transmitters. The splatter sounds like poorly tuned SSB but it cannot be resolved away from the nominal carrier frequency and it gets stronger as you tune towards the nominal frequency. I have heard it said that very strong good signals can cause a weak receiver front end (unable to cope with large signals) to produce similar effects although I am not sure it sounds the same. It certainly does not produce the type of effect that strong broadcast stations do when present in a weak front end - they produce a type of mushy signal that is uniform across all the band whereas splatter is centred on the offending transmitter's carrier frequency. The usual forms of transmitter output low pass filtering are useless at removing the unwanted output signals that cause splatter and it can occur in broadband or tuned output stages.

Limiting is actually caused when the RF output devices try to produce a larger instantaneous RF voltage than the DC supply will permit; caused by an excessively large input signal, it is usually the negative swing which is most troublesome. The device output voltage suddenly has to stop going negative when the device is turned fully or hard on thus clamping the output to the zero volt or ground line - this process is also known as "bottoming" and can occur in class A, B or C output stages. With a class A output stage, a similar effect can occur on positive swings, caused by the DC standing current being less than the instantaneous RF current preventing the RF voltage from rising any further - so called "current limiting" as opposed to the voltage limiting which occurs when bottoming.



The following comments on setting up apply to both the Yeovil and Tiny Tim since their general block diagram is similar - see the sketch above for a typical superhet transmitter. The important thing to remember, when setting up, is not to overdrive the output stage. You should start by turning back the drive control or preset to make certain there is no possibility of the output stage limiting; this setting can be confirmed by checking that the output power is well below, perhaps a quarter of the rated power output. You then need to set the audio presets so that the final mixer stage is just about to limit. For the Yeovil there are two, one for the CW TX sidetone and one for the mike gain. For Tiny Tim there is only the mike gain preset. Monitor the rig output and wind these presets up to just below the point of maximum output. You can whistle or say Aaaaah. If you have a scope then use a long timebase and you can see when the output ceases to go up but there will be sections in between the peaks when the RF output is much lower. If you have to use a mechanical power output meter, it averages out these periods of low output making the reading appear significantly lower; you should adjust the speech presets so the output is about 75 to 80% of the maximum for that drive setting, for the CW TX sidetone preset go for 90 to 95% of max. output since there is no averaging effect on a continuos steady output. Increasing the speech presets beyond the points indicated will give a degree of speech processing by allowing the mixer to limit on speech peaks thus raising the average level of output - it should be done with caution however. The harmonics this produces are removed by the following bandpass RF filters. After you have done the audio presets you can now increase the drive preset to get the transmitter output up to its rated level. Again observe the output and increase the drive preset to just below the point of maximum output - say 90%. On the Yeovil there is some interaction with the trimmer capacitor which attenuates the drive on 80m so you must check on both bands. After the tests, get a nearby amateur to listen carefully to your signal and report critically on what he hopefully doesn't hear (hoping his front end does not overload!). Tim Walford G3PCJ



The Coker

Finally, and to fill a hole, I thought you might like to see what the Coker looks like. Versions are available for 80 and 160m. The RX for the other bands are fine but the TX suffered too much chirp on 40m upwards. If you have a photo that might be suitable for inclusion with a note then I should be able to scan it with my new computing toy! G3PCJ